SYNOPSIS

Studies on Macrofungal Diversity of Hamirpur Region, Himachal Pradesh

Submitted By:
Ms. Jyoti Pathania

Enrollment No.: H11840

Name of Supervisor:
Dr. Hem Chander

Registration No.: H1529

Session: 2017-18

Department of Bio-Sciences, Division Botany
School of Basic & Applied Sciences

CAREER POINT UNIVERSITY,

HAMIRPUR (H. P.)

Introduction:

Fungi are eukaryotic heterotrophs. These lack photosynthetic capacity and have saprophytic or parasitic mode of nutrition (Ainsworth et al. 1973; Webster and Weber 2007). Macrofungi include fungal taxa that produce macroscopic fructifications (ascomata in case of ascomycota and basidioma in case of basidiomycota) for their reproduction. These comprise about 10% of the total fungal diversity of the World (Rossman 1994). Macrofungi belong to Ascomycota, Basidiomycota and Zygomycota. Morphological and anatomical characters of ascomata and basidioma have decisive role in macrofungal taxonomy. Macrofungi are categorized into fleshy fungi (mushrooms), polypores, cup fungi, jelly fungi and puffballs etc. Most of these are edible, medicinally important and considered as one of the important non-timber forest products (Boa 2004).

Mushroom is the fleshy, spore-bearing fruiting body of a fungus (mostly belonging to Basidiomycota and Agaricomycetes). Most of the mushrooms are edible (e.g. *Agaricus bisporus*) and are known as the "meat" of vegetable World (Haas and James 2009). Puffballs are gasteroid fungi that produce gasterothecium (gasteroid basidiocarp) having an outer peridium that encloses a mass of spores. After maturation a large number of basidiospores are released through an apical pore or by dis-integration of peridium (Pegler et al. 1995). Puffballs are generally saprobic, terricolous and humicolous; however, a few (e.g. *Morganella* sp.) grow on decomposing wood (Bates 2004). Jelly fungi belong to Tremellales, Dacrymycetales, Auriculariales and Sebacinales. These are having foliose, gelatinous and irregularly branched fruiting body. On drying these become hard and shriveled; when exposed to water, they return to their original form e.g *Auricularia auricula* and *A. polytricha*. Most of these are edible. Bracket fungi or shelf fungi belong to Basidiomycota (Kirk et al. 2008). They produce shelf or bracket-shaped fruiting bodies that lie in a close group of horizontal rows e.g. *Trametes versicolor*. Cup fungi belong to family Pezizaceae of Ascomycota. Its members produce cup shaped fruiting bodies e.g *Aleuria aurantia*, *Sarcoscypha coccinea* etc.

Fungi fruiting on woody substrata are usually either saprobes or plant pathogens. The wood inhabiting fungi include taxa belonging mainly to Agaricomycetes, Xylariaceae and Ascomycota. The wood inhabiting fungi that dgrade the wood components are known as wood rot fungi (Mishra et al. 2015). There are three main types of decay fungi (white rot fungi, brown rot fungi and soft rot fungi)

which are distinguished by wood components that they degrade. White rot fungi have the ability to degrade cellulose, hemicellulose and lignin resulting in fibrous and bleached wood. Brown rot fungi degrade only the polysaccharide components and residual wood is a brown lignin framework that is characterized by cubical shrinkage and wood collapse. Soft rot fungi can degrade only cellulose and hemicellulose. They can tolerate very wet conditions and the rot is characterized by loss in mechanical strength and the wood becomes wet and spongy (Dix and Webster 1995).

Most of the macrofungi exhibit bioluminescence. Bioluminescent fungi emit a greenish light at a wavelength of 520–530 nm. The light emission is continuous and occurs only in living cells (Okane et al. 1990). Bioluminescence may occur in both mycelia and fruit bodies, as in *Panellus stipticus* and *Omphalotus olearius*, or only in mycelia and young rhizomorphs, as in *Armillaria mellea* (Wassink 1998). In *Roridomyces roridus* luminescence occurs only in the spores, while in *Collybia tuberosa*, it is only in the sclerotia (Moore et al. 2011).

Macrofungi play a central role in many microbiological and ecological processes, influencing soil fertility, decomposition, re-cycling of minerals and organic matter, as well as plant health and nutrition. Also they are the key in recycling dead vegetation. These make the nutrients available for the successive plant communities, provide a source of evolutionary pressure as plant pathogens and keep rampant monoculture plant populations in check. They form symbiosis with the vast majority of herbaceous and woody plants, allowing them to colonize poor soils and utilize otherwise unavailable nutrients from the soil. Macrofungi have great economic importance and are grown all over the World as a source of food as well as for medicinal purpose e.g. *Lentinula edodes* (Vane 2003). Most of the polyporoid fungi are medicinal and edible e.g. *Ganoderma lucidum*, *Trametes versicolor* and *Ganoderma applanatum* (Bishop et al. 2015).

Literature Review:

Macrofungi are among the most mysterious life forms (Sesli and Tuzen 1998). It is estimated that only 16-41% of macrofungi have been described in the World (Mueller et al. 2007). These still remains understudied over most of the parts of World including India (Winterhoff 1992).

The earliest studies on diversity of macrofungi in India pertain to floristic explorations by Berkeley. He studied fungi collected by Dr. Hooker and published flora of Sikkim -Himalayan fungi (Berkeley 1851). He has documented Sikkim and Khassyan fungi (Berkeley 1852) and consolidated account of fungi in India (Berkeley 1854). *Polyporus guhae* and *Trametes karii* were discovered as new species of polypore fungi from Bengal (Bose 1924). Banerjee has contibuted to diversity of higher fungi of Sikkim Himalayas (Banerjee 1946). He also contributed to fungal flora of Calcutta and surrounding areas (Banerjee 1947). Long and Ahmad described the genus *Tylostoma* (Long and Ahmad 1947). Vasudeva in his study supplemented to account of fungi of India (Vasudeva 1952). Thind and Anand studied Clavariaceae of the Mussoorie Hills (Thind and Anand 1956a, 1956b). Corner et al. made additions to Clavariaceae of Mussoorie Hills (Corner et al. 1956, 1957, 1958). Thind and Dev modified the list of Clavariaceae of the Mussoorie Hills (Thind and Dev 1956, 1957a, 1957b). Thind and his associates documented Pezizaceae of the Mussoorie Hills (Thind and Batra 1957a, 1957b; Thind et al. 1957a, 1957b; Thind et al. 1958a, 1958b; Thind et al. 1959). Thind and Raswan studied Clavariaceae of the Mussoorie Hills (Thind and Raswan 1958). The larger fungi, the clavariaceae, the agarics and the Discomycetes received study from K. S. Thind and his group. He has done a lot of research work on Indian Clavariaceae (Thind 1961a, 1961b; Thind and Rattan 1967, 1972). Thind et al. studied Helotiales of Mussoorie Hills (Thind et al. 1961). Agnihothrudu and Barua have described *Trichoglossum hirsutum var. longisporum* from India (Agnihothrudu and Barua 1962). Thind et al. have described the diversity and distribution of Helotiales and Pezizales in India (Thind et al. 1964a, 1964b, 1965, 1966, 1967). Bakshi documented diversity of Polyporoid fungi in India (Bakshi 1966, 1971). Thind and Waraitch have done a lot of work on Xylariaceae of India (Thind and Waraitch 1969, 1976). Thind et al. published an account of Polyporaceae of India (Thind et al. 1969a, 1970). Thind and Rattan contributed to Polyporaceae of India (Thind and Rattan 1971). Bakshi documented Indian polypores and edible fungi (Bakshi 1971; Bakshi and Puri 1978). Pande contributed to the Xylariaceae of Western India (Pande 1973, 1976). An account of Aphyllophorales of India was published (Thind 1973). Kaul and Kachroo reported common edible mushrooms of Jammu & Kashmir (Kaul and Kachroo 1974). Diversity and distribution of *Scytinostroma* in India was documented (Rattan 1974). Ryvarden and Dhanda recorded two polypores from India (Ryvarden and Dhanda 1975). Thind and Dargan worked on Xylariaceae of

India (Thind and Dargan 1975, 1978a, 1978b). Purkayastha and Chandra have worked on Indian edible mushrooms and published morphological information of one hundred and twenty two species of edible mushrooms distributed in India (Purkayastha and Chandra 1976). Sathe and Rahalkar published records of polyporaceae and Agaricales from South West India (Sathe and Rahalkar 1976, 1978). Dhanda documented Polyporaceae of North Western Himalaya (Dhanda 1977). Rattan studied the resupinate Aphyllophorales of North Western Himalayas (Rattan 1977). Khurana studied Clavarioid fungi of India (Khurana 1977). Watling documented Indian agarics (Watling 1978). Bilgrami compiled records of Indian fungi (Bilgrami et al. 1979, 1981, 1991). Studies on Xylariaceae of India recorded genus *Rosellinia* and *Peridoxylon* in India (Dargan and Thind 1979, 1984). Pathak and Gupta reported fifty eight species of agarics distributed among twenty five genera from the Lucknow area (Pathak and Gupta 1979). Sathe reviewed the work done on Indian Agaricales and studied Agaricales (mushrooms) of South West India (Sathe 1979, 1980; Sathe and Deshpande 1979). Thind and Dhanda consolidated account of Polyporaceae of India (Thind and Dhanda 1979a, 1979b, 1980a, 1980b, 1980c). Thind and Dhanda inventorised macrofungi of Kashmir (Watling and Gregay 1980). Studies on Phacidiales recorded new species from India (Sharma and Sharma 1981a, 1981b, 1983). Joshi recorded three new species of *Helvella* from India (Joshi et al. 1982). Rawla published an extensive inventory of agarics and xylarias of India (Rawla et al. 1982a, 1982b, 1985). There are published records of Gasteromycetes of Indian Himalayas (Thind et al. 1982; Sharma 1982, 1991). Dargan documented the diversity and status of Xylariaceae in India (Dargan 1982, 2006). Sharma published new combinations and records of Helotiales (Sharma 1982a, 1982b). A check-list alongwith a key to the species of Indian agaricoid and boletoid basidiomycetes was published (Manzula 1983). Diversity studies on Xylariaceae of Himalayas recorded new species from India (Rawla and Narula 1984; Narula et al. 1984, 1985). Check-list of macrofungi of Himalaya with notes on their distribution was published (Sharda 1984, 1987, 1991). Extensive studies on diversity of clavarioid fungi recorded many new species from Himalayas (Thind and Sharda 1984, 1985a, 1985b, 1985c, 1987). Sarwal studied systematic of Indian Agarics (Sarwal 1984). Narula and Rawla have studied the genus *Kretzschmaria* (Xylariaceae) from Eastern Himalayas and also recorded *Podosordaria maxicana* (Narula and Rawla 1985, 1986). Four new species of Helotiales were recorded from the Indian Eastern Himalayas (Raitvir et al. 1985).

Studies on the distribution of Cyphellaceae and Helotiales in Western Himalayas have recorded new combinations and three new species of *Lambertella* (Sharma 1985a, 1985b, 1985c). The distribution and diversity of genus *Lanzia* in India was documented (Sharma and Sharda 1985). Taxonomic studies on Geoglossaceae of Eastern Himalayas recorded *Maasoglossum* as a new genus (Thind and Sharma 1985). Diversity of Thelephoroid fungi in Eastern Himalayas was published (Thind and Dhingra 1985). Thind et al. documented gasteromycetes of Himalayas (Thind et al. 1985). Sharma studies Cyphellaceae, Ascomycetes, Hyaloscyphaceae, wood rot polypores and Helotiales of Indian Himalaya (Sharma 1985a, 1985b, 1986a, 1986b, 1986c, 1986d, 1989, 1991a, 1991b, 1991c). Sharma and Singh added new species and records of Himalayan Helotiales (Sharma and Singh 1985). The compiled lists of Indian edible mushrooms include 283 species of larger fungi (Purkayastha and Chandra 1985). Thind and Sharma documented new generic and specific records of Helotiales from Indian Himalayas (Thind and Sharma 1986). Kaushal and Virdi recorded Himalayan species of *Saccobolus* and genera of Pezizales (Kaushal and Virdi 1986). A new species of *Penziga* (Xylariaceae) was recorded from India (Narula and Prasher 1986). Sharda and Thind have worked on Genus *Ramaria* in the Eastern Himalaya (Sharda and Thind 1986). Sharma and Rawla added new species to Ascomycetes of India (Sharma and Rawla 1986). Sharma et al. have documented Eastern Himalayan Helotiales (Sharma et al. 1986). A new species of *Hygrocybe* was identified from India (Sharma et al. 1986). Thind and Sharma documented Gasteromycetes of the Himalayas (Thind and Sharma 1986a, 1986b, 1989). Sharma et al. have studied fleshy fungi of North-Western Himalayas (Sharma et al. 1987). Dhingra have studied the genus *Phlebiopsis* in the Eastern Himalayas (Dhingra 1987). A checklist of wild edible mushrooms from South West India was published (Sathe and Kulkarni 1987). Ascomycetous flora of India was published (Sharma and Sharma 1987). Verma et al. published fleshy fungal flora of North Eastern Himalaya (Verma et al. 1987), documented distribution of *Gomphus floccosus* in India (Verma et al. 1989) and inventorised forest fungi of central India (Verma et al. 2008). Kaushal recorded a new species of *Cookeina* (Pezizales) identified from India (Kaushal 1987). Lakhanpal et al. contributed to fleshy fungi of North Western Himalayas (Lakhanpal et al. 1987). Consolidated account of Helotiales of India was published (Thind and Sharma 1987). Rawla and Arya documented agarics of India (Rawla and Arya 1987, 1991). An account of Gasteromycetes of the Himalayas was published (Thind and Thind 1988).

Saini et al. studied diversity of North Indian Agaricales (Saini et al. 1988, 1989). Fleshy fungi of North-Western Himalayas were documented (Sharma and Lakhanpal 1988). *Tuber himalayense* was recorded from North-West Himalaya as new species of *Tuber* (Zhang 1988). Wood rot fungi of Andaman and Nicobar Islands were documented (Quel 1989). Polypores of Indian Botanic Garden were documented (Sharma and Ghosh 1989). A new species of polypores was recorded from India (Sharma and Wright 1989). A new species of edible *Amanita* was recorded from India (Bhatt and Lakhanpal 1989). Family Russulaceae was reviewed (Atri and Saini 1989). Six new genera of Polyporaceae were recorded from India (Virdi 1989a, 1989b, 1990, 1991, 1992). Kumar et al. studied diversity of Amanitaceae in India (Kumar et al. 1990a). Gasteromycetous fungi of Eastern Himalaya were published (Sharma and Thind 1990). An account of fleshy fungi of North-Western Himalaya was published (Bhatt and Lakhanpal 1990). Quel published inventories of discomycetes of Mussoorie Hills (Quel 1991a, 1991b) and explored medicinally important agarics in Himalaya (Quel 2001). Rawla et al. revised checklist of discomycetes of Mussoorie Hills (Rawla et al. 1991a, 1991b). Kumar et al. conducted studies on ecology of macrofungi in the North-Western Himalayas (Kumar et al. 1990b) and subsequently recorded a new species of *Marasmius* (Kumar et al. 1991). Sharma and Sidhu revised Himalayan Geoglossaceae (Sharma and Sidhu 1991). An account of North-West Himalayan species of *Helvella* was published (Kaushal 1991). Fungal flora of Kashmir region of Jammu and Kashmir was documented (Abraham 1991). Mycoflora associated with pathological problems of some multipurpose tree species of Punjab was published (Dulat 1992). Fleshy fungi of North-Western Himalayas were documented (Lakhanpal and Sagar 1992, 1993). East Himalayan Coniophoraceae was studied (Dhingra 1992). Studie on diversity and endemism among Indian *Helotiales* were published (Sharma and Kamal 1993). Status of conservation and significance of Himalayan forest mycoflora was reviewed (Rawla 1993, 2001). Corticiaceae of North-West Himalaya was published (Dhingra and Singla 1993). Role of *Schizophyllum* in forest ecosystem alongwith an account of wood-rot fungi of Haryana was published (Sharma and Gupta 1994, 2004). Three species of genus *Valsa* were recorded from Eastern Himalayas (Dargan and Sharma 1994). Diversity and distribution of *Polyporus* in India was documented (Roy et al. 1994). Sharma et al. recorded new edible species of *Leucocoprinus* from India (Sharma et al. 1994). Natarajan documented mushroom flora of South India (except Kerala) and presented a list of two hundred thirty agarics

and bolete species distributed among sixty sevevn genera from several states of South India (Natarajan 1995). Mushroom flora of Maharashtra was explored (Patil et al. 1995). New records of *Polyporus* were documented from India (Roy and De 1995). Distribution of Polyporaceae in India was published (Roy and De 1996a, 1996b, 1996c, 1997a, 1997b, 1998a, 1998b). Diversity of *Phellinus* in Bhimashankar forest was documented (Vaidya and Rabba 1995). Mushroom flora of North West Himalaya was compiled (Lakhanpal 1995). Mushroom flora of Punjab, Kerala and Western Himalaya was published (Lakhanpal 1996). A consolidated account of diversity of fungi in India was published (Sarbhoy et al. 1996). A detailed account of fungal wealth of India was published (Bilgrami 1997). Three rare species of macrofungi were recorded from Dalhousie Hills (Dhingra and Singla 1997). Three hundred species of mushrooms and toadstools were recorded from North-Western Himalayas, of which seventy two species were found to be in mycorrhizal relationship with *Abies pindrow*, *Betula utilis*, *Cedrus deodara*, *Picea smithiana*, *Pinus roxburghii*, *P. wallichiana*, *Rhododendron arboreum*, *Quercus incana* and *Q. semicarpifolia* (Lakhanpal 1997). Studies on biodiversity and biosystematics of Agaricales of India were published (Sarbhoy 1998). A new species of *Lachnum* was recorded from Eastern Himalayas (Sharma et al. 1998). The distribution and diversity of *Volvariella* in Kerala (India) was documented India (Pradeep et al. 1998). Edible fungi of Garhwal Himalayas were documented (Sharda et al. 1998). Observations on pathological problems and associated mycoflora of certain important multipurpose trees of Punjab were published (Dargan and Dulat 1998). The records on distribution and diversity of *Morchella* in India were revised (Lakhanpal and Shad 1999). Taxonomy of agarics of Punjab was studied (Atri et al. 2000). New species were added to mushroom flora of Assam (Gogoi et al. 2000). Mushrooms of the Garhwal Himalaya were enumerated (Bhatt et al. 2000).

Frequency of occurrence of mangrove fungi in East coast of India was documented (Sarma et al. 2001). Three new species (*Lactarius abbotanus, L. subindigo* and *L. mayawatianus*) of Russulaceae were recorded from Pindari glacier area of Nanda Devi Biosphere Reserve (Sharma and Das 2001, 2003). Medicinal agarics of Himalaya were documented (Rawla et al. 2001). Status of conservation of mycodiversity in India was reviewed (Kaul 2002). Pathological problems and mycoflora associated with *Dalbergia sissoo* plantations in Punjab were documented (Dargan et al. 2002). A new species of *Lactarius* was recorded from Kumaon

Himalaya, India (Das et al. 2003). Mycoflora associated with multipurpose tree species of North–West India was documented (Lalji 2003). Mycoflora of North-Western Himalayas was explored (Paul and Sharma 2003). A checklist of mangrove-associated fungi along with their geographical distribution was published (Schmit and Shearer 2003). Ecological distribution of *Lactarius* (Russulaceae) in Kumaon Himalaya was studied and a new of subgenus *Lactifluus* was recorded (Das et al. 2004a, 2004b). Diversity of *Lactarius* in Kumaon Himalaya was explored and *Russula compacta* was recorded for the first time from India (Das and Sharma 2004a, 2004b). Seventeen species of macrofungi belonging to basidiomycota were documented from Binsar Wildlife Sanctuary, West Himalaya (Pant and Gupta, 2004). *Rhodocybe paurii* was recorded as a new species from Garhwal Himalaya (Moncalvo et al. 2004). The fungal diversity and its status of conservation in India was documented (Dargan et al. 2005). An account of fungal biodiversity alongwith its distribution, conservation status and scope of prospecting in India was published (Manoharachary et al. 2005). A checklist of Indian agarics and boletes was published (Natarajan et al. 2005a, 2005b). Mycoflora associated with *Bauhinia purpurea* was documented (Dargan et al. 2006). Diversity of hyphomycetous fungi from North Eastern hill forests of Arunachal Pradesh, Assam and Nagaland was documented (Bhatt 2006). Macrofungal diversity in fragmented and disturbed forests of the Western Ghats of India was studied (Brown et al. 2006). Agarics of Eastern Ghats, South India were documented (Siva et al. 2006). Six new species belonging to Russulaceae were recorded from Himalaya (Das et al. 2006a, 2006b, 2006c). Eighteen species of polyporoid fungi were enumerated from buffer zone of Nanda Devi Biosphere Reserve (Prasher and Chander 2006). Studied on the diversity of *Niptera* with particular reference to Himalayan taxa were published (Prasher et al. 2003). Edible and medicinal macrofungi of Chandigarh were documented (Prasher et al. 2007). A new species of *Phellinus* was recorded from Maharastra, India (Foroutan et al. 2007). Checklist of the Clavariaceae of India/Himalayas was reviewed (Prasher and Porwal 2007). Checklists of Gasteromycetes of Indian Himalayas were published (Sharma et al. 2007). Diversity of macrofungi in semi-evergreen and moist deciduous forest of Shimoga district, Karnataka, India was explored (Swapna et al. 2008). Pyrenomycetous fungi of Punjab were documented (Dargan and Singh 2008). New basidiomycetous fungi were recorded from Ratanmahal Wildlife Sanctuary, Gujarat, India (Arya et al. 2008). *Bovista aestivalis* and *Calvatia craniiformis* were added to the list of Indian macrofungi (Syed et

al. 2008). Three macrofungi were enumeratedfrom doda district of Jammu and Kashmir, India (Kumar and Sharma 2008). Macrofungal biodiversity of Kashmir forests was explored and new records of macrofungi were documented from Jammu and Kashmir, India (Ahmad et al. 2008). New species of macrofungi were recorded from India (Beig et al. 2008). Occurrence of macrofungi in the Coromandal coast of Tamil Nadu, Southern India was documented (Mani and Kumarsan 2009). Three new species of genus *Sistotrema* and one species of *Hyphoderma* was recorded from India (Dhingra et al. 2009a, 2009b). A checklist of resupinate, nonporoid Agaricomycetous fungi from North-East India was published (Dhingra et al. 2011). Taxonomy of Agaricomycetous fungi from district Roopnagar, Punjab was studied (Kaur 2012). A checklist of Aphyllophorales of Western Ghats of Maharashtra State, India was published (Ranadive 2011). A consolidated account of aphyllophorales of Himalaya was documented (Sharma 2012). The diversity of resupinate, non-poroid agaricomycetous fungi in the Himalaya and adjoining areas was published (Dhingra 2014). *Radulodon acaciae* was recorded as new species of agaricomycetes from India (Kaur et al. 2014a). Four new species of genus *Hyphoderma* were recorded from Punjab (2014b). *Antrodiella indica* was reported as a new species from India (2015a). *Phlebiopsis punjabensis* was published as new species from India (2015b). One hundred and six species of macrofungi belonging to sixty genera were enumerated from the Nanda Devi Biosphere Reserve and the Valley of Flowers National Park (Chander 2016a, 2016b). The diversity of genus *Phanerochaete* in Punjab and adjoining areas was documented (Kaur et al. 2016). New records of resupinate, non-poroid agaricomycetous fungi were made from India (Kaur et al. 2017). *Phlebia brevibasidia* was recorded as new species from India (2017a). Some new reports of resupinate non-poroid Agaricomycetous fungi from Punjab and adjoining areas were documented (2017b).

Earliest reports of macrofungi from Himachal Pradesh were made by Fries on the basis of explorations of macrofungi in North-Western Himalaya with particular emphasis on its diversity and distribution in Himachal Pradesh (1821, 1823, 1828a, 1828b & 1832). After him a lot of researchers have contributed to diversity and distribution of macrofungi in Himachal Pradesh. Sharma et al. revised mycoflora of Himachal Pradesh (Sharma et al. 1982). Sharma documented Polyporaceae of Himachal Pradesh (Sharma 1985). Dhingra and Rani documented new species of *Pseudotomentella* and *Tomentella* from Dalhousie hills (Dhingra and Rani 1991,

1994). Dhingra and Sood recorded two new species of genus *Tubulicrinis* from Dalhousie hills (Dhingra and Sood 1992). Dhingra and Singla studied Corticiaceae of North-West Himalaya and recorded some interesting and rare species from Dalhousie hill (Dhingra and Singla 1993, 1997). Lakhanpal documented diversity of mushroom mycoflora in the North-West Himalaya with particular reference to Himachal Pradesh (Lakhanpal 1997).

Paul and Sharma documented mycoflora of Himachal Pradesh and recorded additional taxa of fungi from various hosts and substrata (Paul and Sharma 2003). Resupinate aphyllophoraceous fungi associated with some tree species of Himachal Pradesh was published (Singh 2007). Dhingra and Singh documented the diversity of resupinate Aphyllophoraceous fungi of Himachal Pradesh (Dhingra and Singh 2009). Prasher and Ashok documented wood rotting fungi (non-gilled Agaricomycotina) of Himachal Pradesh and polyporoid fungi of district Bilaspur of Himachal Pradesh (Prasher and Ashok 2011, 2013). Resupinate, non-poroid Agaricomycetous fungi of Himachal Pradesh was studied (Kaur 2012). Resupinate polyporales (Agaricomycetes) of Himachal Pradesh have been published (Priyanka 2012). Prasher et al. enumerated polyporoid fungi of district Mandi of Himachal Pradesh (Prasher et al. 2012). A checklist of resupinate, non-poroid agaricomycetous fungi from Himachal Pradesh, India was published (Dhingra 2014). Forty eight species of macrofungi including twenty species of coticioid fungi have been documented from Kangra district of Himachal Pradesh (Ritu et al. 2015). Chander et al. published preliminary studies on diversity of wood inhabiting macrofungi of Hamirpur and Sarkaghat region of Himachal Pradesh (Chander et al. 2017a, 2017b).

Research Gap Identification:

The detailed review of published records of macrofungi reveals that whereas, a lot of exercises to explore macrofungi of India, North Western Himalaya and Himachal Pradesh have been carried out by various workers, however diversity of macrofungi in Hamirpur is data deficient and understudied. Only twenty two species of macrofungi have been reported so far from Hamirpur district (Chander et al. 2017a, 2017b). There are least studies pertaining to diversity, mapping of distribution, status, substrate relationship, economic and ecological importance of macrofungi in the study area.

Objectives:

The main objectives of the study are:

1. To collect macrofungi from different localities and substrates.
2. To study morphology and anatomy of each specimen.
3. To identify species and preserve specimens for future reference.
4. To assess and document status (threatened, rare, endangered, common), diversity and distribution of each species.

Proposed Methodology:

Materials: The study area for the proposed research will be Hamirpur district of Himachal Pradesh. It lies in the subtropical climatic zone of Shivalik hills in Western Himalaya. Specimens of macrofungi and related field data concerning their distribution, status, economic and ecological values will be collected throughout the research period from different loaclities and substrates in and around the study area. Total geographical area of Hamirpur district is 1,118 km^2, of which 219 km^2 area (19.6%) is under forest. It is situated between 76°17'50" to 76°43'42" East longitudes and 31°24'48" to 31°53'35" North latitudes. It is located in the South Western part of Himachal Pradesh. It is covered by lower Himalayas (Shivalik hills) and the elevation varies from 400 m to 1,232 m. The maximum temperature of the district ranges from 37°C to 39°C during summer season and the minimum from 3°C to 5°C during winter season. Average temperature is 21.6°C. Annual precipitation is about 1572 mm. The driest month is November, with 14 mm of rainfall. Most precipitation falls in July, with an average of 478 mm. The warmest month of the year is June, with an average temperature of 30.3°C. In January, the average temperature is 11.7°C. It is the lowest average temperature of the whole year. The difference in precipitation between the driest month and the wettest month is 464 mm. The average temperatures vary during the year by 18.6°C. The main hill ranges of the district are known as Jakh Dhar & Sola Singhi Dhar. These ranges are covered with pine forests. The Jakh dhar runs in continuation of Kali Dhar range in the Kangra district. It enters in Hamirpur district near Nadaun and transverses it into South-Eastern direction. Hamirpur district is bounded in the North by river Beas which separates it from Kangra district. In the East, Bakar and Seer Khads separate it from Mandi district. In the South, It is bounded by Bilaspur district and in the west by Una district.

Figure: Map of study area (Source: www.indiamapsonline.com)

The forests of the study area are of two types (Champion and Seth, 1968):

1. Shiwalik chil pine forests: The chil (*Pinus roxburghii*) is the dominant species and occurs in the zone ranging from 600 m to 1,100 m height. It generally forms pure forest on the Western and South-Western slopes of the Jakh Dhar and in the Chabutra Dhar, the proportion of chil is reduced and scrubs of miscellaneous broad leaved species cover the ground.

2. Northern dry mixed deciduous forests: Khair (*Acacia catechu*) is the predominant species. However, besides it, other broad leaved species are also found. The altitudinal range is from 400 m to 850 m. The various species of plants and forest trees found in the district are Kikar, Amla, Neem, Karal, Taur, Bil, Kasmal, Khair, Ber, Chil etc.

Methods: The specimens will be collected randomly from various localities and substrates with the help of equipments such as a sharp knife, a saw etc. Efforts will be made to collect mature specimens. Hand lens (20X) will be used for examination of fructifications in the field. Important details concerning the specimen such as the size and type of fructifications, color of hymenial and abhymenial surfaces, annual/perennial nature, shape etc. will be recorded in the field note-book. Specimens will be photographed at the site of collection (wherever possible) or in the laboratory. Field data to be recorded during collection includes: collection number, details of locality, type of host/substrate, attachment of the fructification/s with host/substrate, name and approximate altitude (in meters) of locality and date of collection. The collected specimen will be sun dried and placed in paper packets/cardboard boxes of suitable size. A paper slip containing the field data will be placed/pasted in/on each paper packet/cardboard. Specimens will be brought to laboratory for further micro and macromorphological studies.

Spore print: A glass slide will be placed on a black chart paper and a portion of the selected fructification will be placed on a glass slide with poroid surface facing the slide. To avoid dust and other spores from the atmosphere, these will be covered with cellophane paper and kept at an undisturbed place overnight. Next morning spore prints will be checked and the slide with spore print will be covered with another clean slide, fixed with tape and packed in the butter paper envelop along with the folded black chart paper. After assigning the respective collection number, spore prints will be packed in cardboard box alongwith the specimen.

Laboratory observations: Microscopic observations will be recorded by using light microscope. All the measurements will be taken in 5% KOH solution. Common mountants/stains to be used for microscopic study include:

1. Cotton Blue: It is best suited for the study of spores. It stains the cytoplasm of fungal cells.
2. Phloxine: Phloxine imparts red colour to the fungal cortex. It makes the structures of the ascus wall and septation of the ascospores clearly visible. For this purpose, 1% aqueous solution of Phloxine will be used.
3. Glycerine: 50 % aqueous solution of Glycerin will be as used as mountant to make permanent slides and to remove excess stain.

For the study of ascomycetous fungi, the dried specimens will be revived in 2% KOH and all the measurements will be recorded in this reagent. Different mountants will be used to study different parts of the fructifications such as thin sections of the ascocarp will be stained with Potassium hydroxide-phloxine-glycerine stain, the blueing of the ascus tip will be observed with Melzer's reagent (0.5g iodine + 1.5g potassium iodide + 20g chloral hydrate + 20ml distilled water), ascospore ornamentation cyanophily of microscopic structures will be observed with cotton blue (the thin sections will be heated gently in a drop of this stain till the white fumes start coming out) whereas the congo red will be used to stain ascus wall, paraphyses, ascospores & excipular tissues.

For the study of basidiomycetous fungi, the sections of fructifications will be mounted in 2% KOH for measurements of various structures as basidiospores, basidia, cystidia, setae and stained with cotton blue (for determining the cyanophilous reaction), Melzer's reagent (for determining the amyloidity), 1% aqueous solution of congo red and phloxine (to determine the presence or absence of clamps and for measuring hymenial elements and hyphae) and sulfobenzaldehyde (for staining gloeocystidia).

Identification: The morphological and anatomical details will be compiled in the form of a description which will then be compared with the published literature, authenticated taxonomic keys and monographs.

Drying and preservation: Specimens will be sundried in the field and laboratory. Fresh fleshy fructifications will be put on blotting paper sheets with their hymenial surface facing upwards for drying in the bright sunlight. On rainy days these will be dried in an electric drier or in an oven at 40°C. Dried specimens will be packed in paper envelops/cardboard boxes of suitable sizes. For the preservation of dried specimens, 1,4-dichlorobenzene crystals will be put into each packet for protection from attack of worms, insects etc. The specimens will be allotted herbarium accession number and deposited in CPUH (Herbarium of Department of Bio-Sciences, Career Point University, Hamirpur).

Thesis Outline:

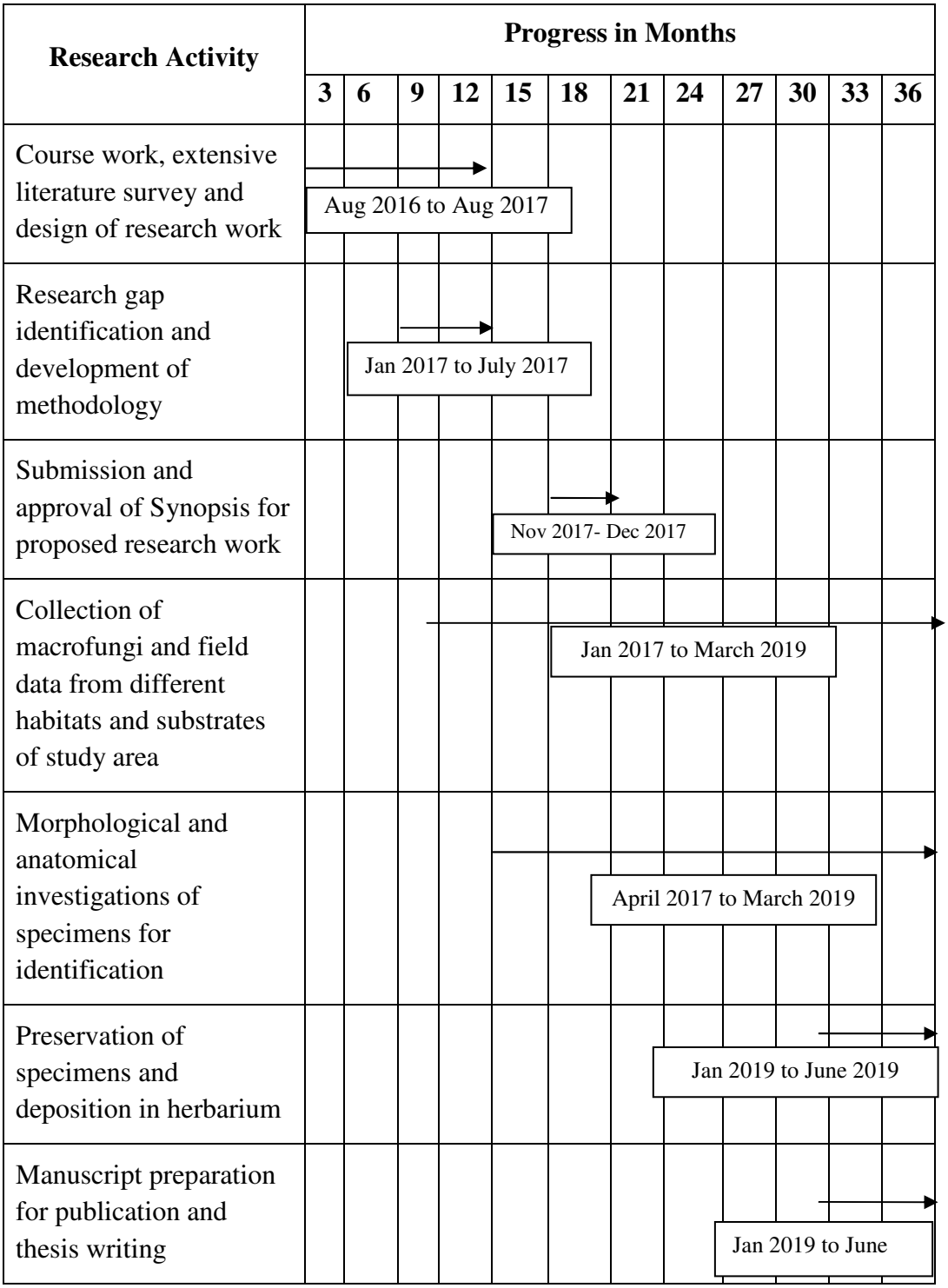
Thesis will comprise seven chapters as:

1. **Chapter 1** (Introduction): It will include general information about the diversity, growth forms, host-substrate relationship, economic importance, ecological importance, status and distribution of macrofungi. It will also include objectives of the study and the research gaps that originated the need for the present study.
2. **Chapter 2** (Literature Review): It will deal with the detailed review of the literature concerning earlier and recent finding by various mycologists on diversity and distribution of macrofungi in the World, India and Himalaya with particular reference to North Western Himalaya and Himachal Pradesh.
3. **Chapter 3** (Materials and Methods): It will provide the details about the general geography, climate and vegetation of the study area. It will also include methodology of collection, field studies/observations, morphological investigations, anatomical studies, identification and preservation of species.
4. **Chapter 4** (Observations): In this chapter all the species will be described morphotaxonomically and arranged alphabetically in the order: family-genus-species. The taxonomic key to families, genus and species will be presented for identification of macrofungi. The following data will be presented for each taxa:
   - Brief description of family along with authority, citation and distribution.
   - Taxonomic key to the genera.
   - Brief description of genus along with authority, citation, distribution, status, economic, ecological importance and remarks (if any).
   - Taxonomic key to the species.
   - Morpho-chemotaxonomic description of species along with authority, citation, herbarium accession number, substrate, locality, date of collection, distribution, status, economic, ecological importance and remarks.
   - Photographic image of species.
5. **Chapter 5** (Results and Discussion): It will include the results of analysis of diversity studies, macrofungi-substrate relationship, assessment of status (threatened, rare, endangered, common) of species, documentation of economic and ecological value of species.
6. **Chapter 6** (Conclusion and Summary): Comprises summary of entire study according to objectives along with conclusions. It will include inventory of

recorded species along with their distribution and threat status. The scope of further research will also be discussed.

7. **Chapter 7** (References): The pattern of citing references will be according to guidelines of Mycologia (An official Journal of Mycological Society of America).

Research Plan Schedule:


Research Activity
Progress in Months
3
6
9
12
15
18
21
24
27
30
33
36
Course work, extensive literature survey and design of research work
Aug 2016 to Aug 2017
Research gap identification and development of methodology
Jan 2017 to July 2017
Submission and approval of Synopsis for proposed research work
Nov 2017- Dec 2017
Collection of macrofungi and field data from different habitats and substrates of study area
Jan 2017 to March 2019
Morphological and anatomical investigations of specimens for identification
April 2017 to March 2019
Preservation of specimens and deposition in herbarium
Jan 2019 to June 2019
Manuscript preparation for publication and thesis writing
Jan 2019 to June

References:

1. Abraham SP. 1991. Kashmir fungal flora- an overview. In: Nair MC, ed. Indian Mushrooms. Vellanikara, India: Kerala Agricultural University. P. 13-24.
2. Agnihothrudu V, Barua GCS. 1962. *Trichoglossum hirsutum* (Pers. ex Fr.) Bourd. *var. longisporum* (Tai) E.B. Mains from Assam with a note on the Indian Geoglossaceae. Current Science 31(9):386-387.
3. Ahmad BM, Hassan DG, Ganai NA, Ahmad KN. 2008. Mycological biodiversity in Kashmir forests and some new records of macrofungi from J&K state. Applied Biological Research 10(1-2):26-30.
4. Ainsworth GC, Sparrow FK, Sussman AS. 1973. The Fungi: An advanced treatise. Vols. 4A & 4B. New York: Academy Press.
5. Arya A, Albert S, Nagadesi PK. 2008. New and interesting records of basidiomycetous fungi from Ratanmahal Wildlife Sanctuary, Gujarat, India. Journal Mycology and Plant Pathology 38(2):221-226
6. Atri NS, Saini SS. 1989. Family Russulaceae Roze: A review. In: Trivedi ML, Gill GS, Saini SS. eds. Plant Science Research in India. New Delhi: Today and Tommorrow's Printers and Publishers. p. 115-125
7. Atri NS, Saini SS, Kaur A. 2000. Taxonomical studies on agarics from Punjab: the genus *Lepiota* (Pers. ex Fr.) Gray. Mushroom Research 9(2):71-77.
8. Bakshi BK, Puri YN. 1978. Edible Fungi: their survey and cultivation. Indian Mushrooms Science 1:374-381.
9. Bakshi BK. 1966. Indian Polyporaceae. New Delhi: Indian Council of Agricultural Research.
10. Bakshi BK. 1971. Indian polyporaceae (on trees and timber). New Delhi: Indian Council of Agricultural Research. p. 246.
11. Banerjee SN. 1946. Some higher fungi of the Sikkim Himalayas. Scientific Culture 11:444-445.
12. Banerjee SN. 1947. Fungus flora of Calcutta and sub-urbs. Bulletin of Botanical Society of Bengal 1:35-54.
13. Bates ST. 2004. Arizona members of the Geastraceae and Lycoperdaceae (Basidiomycota, Fungi). Master Thesis. USA: Arizona State University.
14. Beig MA, Dar GH, Ganai NA, Quazi NA. 2008. Some hitherto unrecorded macrofungi from India. Journal Mycology and Plant Pathology 38(2):208-210.

15. Bhatt RP, Lakhanpal TN. 1989. A new record of edible *Amanita* from India. Current Science 58(11):627-628.

16. Bhatt RP, Lakhanpal TN. 1990. Fleshy fungi of north-western Himalayas-V. Indian Phytopathology 43(2):156-164.

17. Bhatt VP, Bhatt RP, Gaur RD. 2000. Mushrooms of the Garhwal Himalaya: The genus *Lactarius* Pers. ex. S.F. Gray. Mushroom Research 9(1):11-18.

18. Bhatt DJ. 2006. Hyphomycetous fungal diversity in the North Eastern hill forests of Arunachal Pradesh, Assam and Nagaland. Kavaka 34:27-48.

19. Bidartondo MI. 2005. The evolutionary ecology of myco-heterotrophy. Journal of New Phytology 167:335-352.

20. Bilgrami KS, Jamaluddin, Rizvi MA. 1979. The Fungi of India Part-I (List and Reference). New Delhi: Today and Tomorrow's Printers and Publishers. 467 p.

21. Bilgrami KS, Jamaluddin, Rizvi MA. 1981. The Fungi of India Part-II (Host Index and Addenda). New Delhi: Today and Tomorrow's Printers and Publishers. 128 p.

22. Bilgrami KS, Jamaluddin, Rizvi MA. 1991. The Fungi of India Part-III (List and References). New Delhi: Today and Tomorrow's Printers and Publishers. 798 p.

23. Bilgrami KS. 1997. Fungal wealth of India. Proceedings of Indian Academy of Sciences 63(3):269-280.

24. Bishop KS, Kao CHJ, Xu YG, Marcus P, Paterson R, Russell M, Ferguson, Lynnette R. 2015. From 2000 years of *Ganoderma lucidum* to recent developments in nutraceuticals. Phytochemistry 114:56–65.

25. Borchers AT, Krishnamurthy A, Keen CL, Meyers FJ, Gershwin ME. 2008. The immunebiology of mushrooms. Experimental Biology and Medicine 233(3):259–76.

26. Bose SR. 1924. Three new species of Bengal Polyporaceae. Botanical Gazette 78(1):19-121.

27. Brem FM, Lips KR. 2008. *Batrachochytrium dendrobatidis* infection patterns among Panamanian amphibian species, habitats and elevations during epizootic and enzootic stages. Diseases of Aquatic Organisms 81(3):189–202.

28. Brown N, Bhagwat S, Watkinson S. 2006. Macrofungal diversity in fragmented and disturbed forests of the Western Ghats of India. Journal of Applied Ecology 43(1):11-17.

29. Champion HG, Seth SK. 1968. A revised forest types of India. Dehradun, India: Natraj Publishers. 404p.

30. Chander H. 2016a. Diversity and distribution of macrofungi in the Valley of Flowers National Park. Journal of Biological and Chemical Chronicles 2(2):36-41.

31. Chander H. 2016b. Diversity and distribution of macrofungi and lichens in the Nanda Devi Biosphere Reserve. In: Arya MK, Bharti PK, Joshi R, eds. Biological Diversity and Ecology. New Delhi: Discovery Publishing House. p. 184-207.

32. Chander H, Devi K, Dogra A. 2017a. Preliminary investigations on diversity of wood rot fungi in Hamirpur district, Himachal Pradesh. Journal of Biological and Chemical Chronicles 3(2):10-14.

33. Chander H, Thakur S, Sharma S. 2017b. Investigations on diversity of wood inhabiting fungi in Sarkaghat region of Districtt Mandi, Himachal pardesh, Northwestern Himalaya. Journal of Biological and Chemical Chronicles 3(1): 41-54.

34. Corner EJH, Thind KS, Anand GPS. 1956. The Clavariaceae of the Mussoorie Hills (India)-II. Transaction of the British Mycological Society 39:475-484.

35. Corner EJH, Thind KS, Dev S. 1957. The Clavariaceae of the Mussoorie Hills (India)-VII. Transaction of the British Mycological Society 40:472-476.

36. Corner EJH, Thind KS, Dev S. 1958. The Clavariaceae of the Mussoorie Hills (India)-IX. Transaction of the British Mycological Society 41:203-206.

37. Dadachova E, Bryan RA, Huang X, Moadel T, Schweitzer AD, Aisen P, Nosanchuk JD, Casadevall A. 2007. Ionizing radiation changes the electronic properties of melanin and enhances the growth of melanized fungi. PloS One. 2(5): 457.

38. Dargan JS, Thind KS. 1979. Xylariaceae of India-VII: The genus *Rosellinia* in the Northwest Himalayas. Mycologia 71(5):1010-1023.

39. Dargan JS. 1982. *Xylaria musooriensis*: A new species from India. Mycologia 74(3):523-525.

40. Dargan JS, Thind KS. 1984. Genus *Peridoxylon* Shear in India. Journal of Indian Botanical Society 63(2):177-180.

41. Dargan JS, Sharma AK. 1994. Genus *Valsa* Fr. in Eastern Himalayas. Kavaka 19(1-2):27-31.

42. Dargan JS, Dulat A. 1998. Observations on the pathological problems and associated mycoflora of certain important multipurpose trees of Punjab-II. Journal of Indian Botanical Society 77:47-52.

43. Dargan JS, Dhingra GS, Lalji K. 1999. Observations on the pathological problems and associated mycoflora of certain important multipurpose trees of Punjab-III. Journal of Indian Botanical Society 78:387-388.

44. Dargan JS, Dhingra GS, Lalji K. 2002. Pathological problems and mycoflora associated with *Dalbergia sissoo* plantations in Punjab. Plant Disease Research 17(2):269–277.

45. Dargan JS, Atri NS, Dhingra GS. 2005. The Fungi: Diversity and conservation in India. Dehra Dun, India: Bishen Singh Mahendra Pal Singh. 316 p.

46. Dargan JS. 2006. Family Xylariaceae: Status and progress in India. Kavaka 34:1-16.

47. Dargan JS, Dhingra GS, Lalji K, Singh AP. 2006. Mycoflora associated with *Bauhinia purpurea* Linn. Bionature 26(1):33-38.

48. Dargan JS, Singh M. 2008. Pyrenomycetous fungi of Punjab-III: *Xylaria punjabensis sp. nov*. from India. Nordic Journal of Botany 2(1):71-73.

49. Das K, Sharma JR, Verbeken A. 2003. New species of *Lactarius* from Kumaon Himalaya, India. Mycotaxon 88:333-342.

50. Das K, Sharma JR. 2004a. *Lactarius* in Kumaon Himalaya 2: New and interesting species of subgenus *Plinthogali*. Mycotaxon 89(2):289-296.

51. Das K, Sharma JR. 2004b. *Russula compacta* Frost & Peck: A new record from India. Journal of Mycology and Plant Pathology 34(1):149-150.

52. Das K, Sharma JR, Montoya L. 2004a. *Lactarius* (*Russulaceae*) in Kumaon Himalaya-1: New species of subgenus *Russularia*. Fungal Diversity 16:23-33.

53. Das K, Sharma JR, Montoya L. 2004b. *Lactarius* in Kumaon Himalaya 3: A new species of subgenus *Lactifluus*. Mycotaxon 90(2):285-290.

54. Das K, Miller SL, Sharma JR, Sharma P, Bhatt RP. 2006a. *Russula* in Himalaya 1: A new species of subgenus *Amoenula*. Mycotaxon 94:85-88.

55. Das K, Miller SL, Sharma JR. 2006b. *Russula* in Himalaya 2: Four new taxa. Mycotaxon 95:205-215.

56. Das K, Sharma JR, Atri NS. 2006c. *Russula* in Himalaya 3: A new species of subgenus *Ingratula.* Mycotaxon 95:271-276.

57. Dhanda RS. 1977. Studies on Polyporaceae of North Western Himalayas. Ph.D. Thesis. Chandigarh, India: Panjab University. 500 p.

58. Dhingra GS. 1987. The genus *Phlebiopsis* in the Eastern Himalayas. Nova Hedwigia 44(1-2):221-227.

59. Dhingra GS, Rani M. 1991. Two New Records of the Genus *Pseudotomentella* from Dalhousie Hills. Geobios New Reports 10:125-127.

60. Dhingra GS. 1992. East Himalayan Coniophoraceae (Basidiomycetes)-I. Some new reports. Geobios New Reports 11(2):118-122.

61. Dhingra GS, Sood S. 1992. Two new records of genus *Tubulicrinis* from Dalhousie Hills. Geobios New Reports 12:62-64.

62. Dhingra GS, Singla N. 1993. Studies in North-West Himalaya Corticeaceae (Basidiomycetes)-I: Some interesting species from Dalhousie Hill. Journal Indian Botanical Society 72:29-33.

63. Dhingra GS, Rani M. 1994. North-West Himalayan Thelephoraceae (Basidiomycetes) Genus *Tomentella* from Dalhousie Hills. Current Research Plant Science. p. 43-56.

64. Dhingra GS, Singla N. 1997. North-West Himalayan Corticiaceae-Three Rare Species from Dalhousie Hills. Geobios New Reports 16: 70-72.

65. Dhingra GS, Singh AP. 2009. Diversity of Resupinate Aphyllophoraceous fungi in Himachal Pradesh: Family Coniophoraceae. Journal of Indian Botanical Society 88(1-2):122-127.

66. Dhingra GS, Priyanka and, Singh AP. 2009a. Three new records of genus *Sistotrema* from India. Journal of Indian Botanical Society 88:76-79.

67. Dhingra GS, Singh AP, Singla N. 2009b. A new species of *Hyphoderma* (Basidiomycetes) from India. Mycotaxon 108:197-199.

68. Dhingra GS, Priyanka, Kaur J. 2011. A checklist of resupinate, nonporoid Agaricomycetous fungi from NorthEast India and Bhutan. Synopsis Fungorum 29:22-70.

69. Dhingra GS. 2014. Diversity of resupinate, non-poroid agaricomycetous fungi in the Himalaya and adjoining areas. In: Singh M, ed. Proceedings of the 8th International Conference on Mushroom Biology and Mushroom Products. p. 24–41.

70. Dhingra GS, Singh AP, Kaur J, Priyanka, Kaur H, Rani M, Sood S, Singla N, Kaur H, Jain N, Gupta S, Kaur M, Sharma J, Rajnish, Kaur G. 2014. A checklist

of resupinate, non-poroid agaricomycetous fungi from Himachal Pradesh, India. Synopsis Fungorum 32:08-37.

71. Finlay RD, Lindahl BD, Taylor AFS, Avery S, Stratford M, Van WP. 2008. Responses of mycorrhizal fungi to stress in yeasts and filamentous fungi. Amsterdam: Elsevier. p. 201-220.

72. Dulat AK. 1992. Mycoflora associated with pathological problems of some multipurpose tree species of Punjab. M.Phil. Thesis. Patiala, India: Punjabi University, Patiala. 135p.

73. Finlay RD. 2004. Mycorrhizal fungi and their multifunctional roles. Mycologist 18:91-96.

74. Foroutan A, Vaidya JG. 2007. Records of new species of *Phellinus* in Maharastra India. Asian Journal Plant Sciences 6(4):633-637.

75. Frey-Klett J, Garbaye J, Tarkka M. 2007. The mycorrhiza helper bacteria revisited. *New Phytology* 176:22-36.

76. Fries EM. 1821. Systema Mycologicum Vol. I. Lundae. 520 p.

77. Fries EM. 1823. Systema Mycologicum Vol. II. Lundae. 621 p.

78. Fries EM. 1928a. Elenchus Fungorum, Sistens Commentarium. Systema Mycologicum 1: 1- 238.

79. Fries EM. 1928b. Elenchus Fungorum, Sistens Commentarium. Systema Mycologicum 2:1-154.

80. Fries EM. 1832 Systema Mycologicum Vol. III. Greifswald. 524 p.

81. Gogoi RD, Majumdar D, Puzari KC. 2000. New additions to mushroom flora of Assam. Mushroom Research 9(1):55.

82. Gregory P, Hirst J. 1957. The summer air spora at Knthamstead. Journal of General Microbiology 7:135-52.

83. Haas EM, James P. 2009. More vegetables, Please! Delicious recipes for eating healthy foods each and every day. Oakland, California: New Harbinger Publications. p. 22.

84. Hyde HA, Adams KF. 1960. Airbone allergens at Cardiff. Acta Allergologica 15(suppl. VII):159.

85. Ibanez MD, Horner WE, Liengswangswong V, Sastre J, Leher SB. 1988. Identification and analysis of basidiospore allergens from puffballs. Journal of Allergy and Clinical Immunology 82:787-95.

86. Jeffries P. 2003. The contribution of arbuscular mycorrhizal fungi in sustainable maintenance of plant health and soil fertility. Biology and Fertility of Soils 37(1):1–16.

87. Johnson D, Leake JR, Ostle N, Ineson P, Read DJ. 2002. In situ $^{13}CO2$ pulse-labelling of upland grassland demonstrates a rapid pathway of carbon flux from arbuscular mycorrhizal mycelia to the soil. New Phytology 153:327-334.

88. Joshi MC, Bishi NS, Harsh NSK. 1982. Three new records of *Helvella* from India. Current Science 51(9): 474-475.

89. Kaul TN, Kachroo JL. 1974. Common edible mushrooms of Jammu and Kashmir. Journal Bombay Natural History Society 71:26-31.

90. Kaul TN. 2002. Conservation of mycodiversity in India. In: Watling R, Frankland JC, Ainsworth M, Robinson CH, eds. Tropical Mycology: Macromycetes. London: CABI. p. 137-147.

91. Kaur G, Singh AP, Dhingra GS. 2014a. *Radulodon acaciae sp. nov.* (Agaricomycetes) from India. Mycotaxon 127:111-113.

92. Kaur G, Kaur H, Singh AP, Dhingra GS. 2014b. Four new records of genus *Hyphoderma* Wallr. from Punjab. Kavaka 42:25-28.

93. Kaur G, Singh AP, Dhingra GS. 2015a. *Antrodiella indica*, a new species from India. Mycotaxon 130(3):625–627.

94. Kaur G, Singh AP, Dhingra GS. 2015b. *Phlebiopsis punjabensis sp. nov.* from India. Mycotaxon 130(3): 907–909.

95. Kaur G, Singh AP, Dhingra GS. 2016. Diversity of genus *Phanerochaete* in Punjab and adjoining areas. Kavaka 46:40-44.

96. Kaur G, Kaur P, Singh AP. 2017. New records of resupinate, non-poroid agaricomycetous fungi from India. Czech Mycology 69(2):205–219.

97. Kaur G, Singh AP, Dhingra GS. 2017a. *Phlebia brevibasidia sp. nov.* from India. Mycotaxon 132(1):95-97.

98. Kaur G, Singh AP, Dhingra GS. 2017b. Some new reports of resupinate non-poroid Agaricomycetous fungi from Punjab and adjoining areas. Kavaka 48(1):64–67.

99. Kaur H. 2012. Taxonomic studies on Agaricomycetous fungi from district Roopnagar. M.Phil. Thesis. Patiala, India: Punjabi University, Patiala. 86 p.

100. Kaur J. 2012. Studies on resupinate, non-poroid Agaricomycetous fungi from Himachal Pradesh. Ph.D. Thesis Patiala, India: Punjabi University, Patiala, India.

101. Kaushal SC, Virdi SS. 1986. Himalayan species of *Saccobolus*, a coprophilous genus of Pezizales. Willdenowia 16(1):269-277.

102. Kaushal SC. 1987. A new species of *Cookeina* (Pezizales) from India. Journal Indian Botanical Society 65(4):404-407.

103. Kaushal SC. 1991. Systematics of North Western Himalayan species of *Helvella* (operculate discomycetes). In: Khullar SP, Sharma MP, eds. Himalayan Botanical Researches. New Delhi: Ashish Publishing House. p. 61-82.

104. Khurana IPS. 1977. Studies on the Clavarioid fungi of India. Ph.D. Thesis. Chandigarh, India: Panjab University.

105. Kirk PM, Cannon PF, Minter DW, Stalpers JA. 2008. Ainsworth and Bisby's Dictionary of the Fungi 10th Edition. London: CABI. 771 p.

106. Kumar A, Bhatt RP, Lakhanpal TN. 1990a. The *Amanitaceae* of India. Dehradun, India: Bishen Singh Mahendra Pal Singh. 160p.

107. Kumar A, Lakhanpal TN, Stephenson SL. 1990b. Ecological studies of some macrofungi in the northwestern Himalayas. Nova Hedwigia 50:535-547.

108. Kumar A, Singer R, Lakhanpal TN, Stephenson SL. 1991. A new species of *Marasmius* from northwestern India. Nova Hedwigia 52:227-230.

109. Kumar S, Sharma VP. 2008. Three larger fungi from doda district of Jammu province, Jammu & Kashmir, India. Journal of Mycology and Plant Pathology 38(1):93-96.

110. Kuo M. 2007. 100 Edible mushrooms. Ann Arbor, Michigan: The University of Michigan Press. p. 79–84.

111. Lakhanpal TN, Sagar A. 1992. Fleshy fungi of N.W. Himalayas-XIV. Three species of *Boletus* new to India. Kavaka 17(1-2):32-37.

112. Lakhanpal TN, Sharma R, Sharma JR. 1987. Fleshy fungi of North Western Himalayas-III. The genus *Gyroporus* (Boletaceae). Kavaka 13(2):91-93.

113. Lakhanpal TN. 1995. Mushroom flora of North West Himalayas. In: Chadha KL, Sharma SR, eds. Advances in Horticulture13: Mushrooms. New Delhi: Malhotra Publishing House. p. 351-373.

114. Lakhanpal TN. 1996. Mushrooms of India: Boletaceae (Vol. 1). New Delhi: Ashish Publishing House. 170 p.

115. Lakhanpal TN. 1997. Diversity of mushroom mycoflora in the North-West Himalaya. In: Sati SC, Saxena J and Dubey RC, eds. Recent Researches in Ecology, Environment and Pollution. New Delhi: Today and Tomorrow's Printers and Publishers. p. 35–68.

116. Lakhanpal TN, Shad OS. 1999. A re-appraisal of the genus *Morchella* in India. In: Tewari JP, Lakhanpal TN, Singh J, Gupta R, Chamola BP, eds. Advances in Microbial Biotechnology. New Delhi: Ashish Publishing House. p. 517-523.

117. Lalji K. 2003. Mycoflora associated with multipurpose tree species of North–West India. Ph.D. Thesis. Patiala, India: Punjabi University, Patiala. 254 p.

118. Le CT, Burgaud G, Mahe S, Barbier G, Vandenkoornhuyse P. 2009. Fungal diversity in deep-sea hydrothermal ecosystems. Applied Environmental Microbiology 75(20):6415–21.

119. Long WH, Ahmad S. 1947. The genus *Tylostoma* in India. Farlowia 3:225-267.

120. Mani S, Kumarsan V. 2009. Occurrence of macrofungi on the Coromandal coast of Tamil Nadu, Southern India. Journal Threatened Taxa 1(1):54-57.

121. Manjula B. 1983. A revised list of the agaricoid and beteloid basidiomycetes from India and Nepal. Proceedings of Indian Academy of Sciences 92: 81-213.

122. Manoharachary C, Sridhar K, Singh R, Adholeya A, Suryanarayanan TS, Rawat S, Johri BN. 2005. Fungal biodiversity: Distribution, conservation and prospecting of fungi from India. Current Science 89(1):58-71.

123. Mishra JK, Tewari JP, Deshmukh SK, Vagvolgyi C. 2015. Fungi from different substrates. London, New York: lCRC Press, Taylor and Francis Group. 61 p.

124. Moncalvo JM, Baroni TJ, Bhatt RP, Stephenson SL. 2004. *Rhodocybe paurii*, a new species from the Indian Himalaya. Mycologia 96:859-865.

125. Moore D, Robson GD, Trinci APF. 2011. 21st century guidebook to Fungi. Cambridge, UK: Cambridge University Press. 246 p.

126. Mordali M, Mostafavi H, Ghodi S, Hedjaroude G. 2007. Immunomodulating and anticancer agents in the realm of macromycetes fungi (macrofungi). International Journal of Immunopharmacology 7(6):701-724.

127. Mueller GM, Schmit PJ, Leacock PR, Buyck B, Cifuentes J, Desjardin DE, Hailing RE, Hjortstam K, Iturriaga T, Larsson KH, Lodge DJ, May TW, Minter D, Rajchenberg M, Redhead SA, Ryvarden L, Trappe JM, Watling R, Wu Q. 2007. Global diversity and distribution of macrofimgi. International Journal of Biodiversity Conservation 16:37-48.

128. Narula AM, Rawla GS, Sharma R. 1984. Three taxa of Xylariaceae new from India. Biovigyanam 10(2):127-129.

129. Narula AM, Rawla GS. 1985. The genus *Kretzschmaria* (Xylariaceae) from Eastern Himalayas. Nova Hedwigia 40(1-4):241-245.

130. Narula M, Rawla GS, Prasher IB. 1985. Xylariaceae of Eastern Himalayas-III. Research Bulletin of Panjab University (Sciences) 36(3-4):161-134.

131. Narula AM, Prasher IB. 1986. A new species of *Penziga* (Xylariaceae) from India. Journal of Indian Botanical Society 65(4):519-521.

132. Narula AM, Rawla GS. 1986. *Podosordaria maxicana* Ell. & Halw.- Xylariaceae: A new generic record from India. Journal Indian Botanical Society 65(4):359-361.

133. Natarajan K. 1995. Mushroom flora of South India (except Kerala). In: Chadha KL, Sharma SR, eds. Advances in Horticulture 13: Mushrooms. New Delhi: Malhotra Publishing House. p. 381-397.

134. Natarajan K, Narayanan K, Ravindran C, Kumarsan V. 2005a. A checklist of Indian agarics and boletes. Kavak 33:11-28.

135. Natarajan K, Narayanan K, Ravindran C, Kumarsan V. 2005b. Biodversity of agarics from Nilgiri Biosphere reserve. Current Science 88(12): 890-1892.

136. Newsham KK, Fitter AH, Watkinson AR. 1995. Multi-functionality and biodiversity in arbuscular mycorrhizas. Trends in Ecological Evolution 10:407-411.

137. Okane DJ, Lingle WL, Porter D, Wampler JE. 1990. Spectral analysis of bioluminescence of *Panellus stypticus*. Mycologia 82(5):607–616.

138. Pande A. 1973. Contributions to the Xylariaceae of Western India-V. Bulletin of Botanical Survey of India 15:8-12.

139. Pande A. 1976. Contributions to the Xylariaceae of Western India-VII. Biovigyanum 2:107-109.

140. Pant S, Gupta RC. 2004. Diversity of macrofungi of Binsar Wildlife Sanctuary in Kumaun, West Himalaya. Indian Journal of Forestry 27(4):334-334.

141. Pathak NC, Gupta S. 1979. Agaric flora of Lucknow. In: Chattopadhyay SB, Smajpati N, eds. Advances in Mycology and Pathology. New Delhi: Oxford and IBH Publishing Company. p. 76-80.

142. Patil BD, Jadhav SW, Sathe AV. 1995. Mushroom flora of Maharashtra. In: Chadha KL, Sharma SR, eds. Advances in Horticulture: Mushrooms. New Delhi: Malhotra Publishing House. p. 317-328.

143. Paul YS, Sharma RC. 2003. Mycoflora of Northwest Himalayas: Himachal Pradesh. Dehradun, India: International Book Distributing Company. 244 p.

144. Pegler DN, Laessoe T, Spooner BM. 1995. British Puffballs, Earthstars and Stinkhorns: An account of the British gasteroid fungi. Kew: Royal Botanic Garden.

145. Pradeep CK, Virinda KB, Mathew S, Abraham TK. 1998. The genus *Volvariella* in Kerala state, India. Mushroom Research 7:53–62.

146. Prasher IB, Sharma MP, Sharma R. 2003. Diversity in the genus *Niptera* with particular reference to Himalayan taxa. Phytomorphology 53(3-4):249-256.

147. Prasher IB, Chander H. 2006. Polyporoid fungi of Nanda Devi Biosphere Reserve. Panjab University Research Journal (Science) 56:123-136.

148. Prasher IB, Porwal G. 2007. A checklist of the Clavariaceae of India/Himalayas.). In: Prasher IB, Sharma MP, eds. Adnaces in Mycology and Plant Pathology. Dehradun, India: Bishen Siungh and Mahendra Pal Singh Publishers. p. 47-79.

149. Prasher IB, Sharma MP. 2007. Advances in Mycology and Plant Pathology. Dehradun, India: Bishen Siungh and Mahendra Pal Singh Publishers. 287p.

150. Prashar IB, Chander H. 2007. A preliminary report on the macrofungi and lichens of Nanda Devi Biosphere Reserve (Uttaranchal). In: Prasher IB, Sharma MP, eds. Adnaces in Mycology and Plant Pathology. Dehradun, India: Bishen Siungh and Mahendra Pal Singh Publishers. p. 175-211.

151. Prashar IB, Sharma P, Chander H. 2007. Edible and medicinal macrofungi of Chandigarh. In: Prasher IB, Sharma MP, eds. Adnaces in Mycology and Plant Pathology. Dehradun, India: Bishen Siungh and Mahendra Pal Singh Publishers. p. 317-330.

152. Prasher IB, Lalita, Ashok D. 2011. Polyporoid fungi of District Bilaspur (H.P.). Journal of Indian botanical Society 90(3- 4): 268-273.

153. Prasher IB, Lalita, Ashok D. 2012. Polyporoid fungi of District Mandi (H.P.). Journal of Indian botanical Society 91(1-2): 204-212.

154. Prasher IB, Ashok D. 2013. A checklist of wood rotting fungi (non-gilled Agaricomycotina) of Himachal Pradesh. Journal on New Biological Reports 2(2):71-98.

155. Prasher IB, Ashok D. 2014a. Wood rotting non-gilled Agaricomycetes new to India. Journal on New Biological Reports 3(1):04-08.

156. Prasher IB, Ashok D. 2014b. Some interesting wood rotting non-gilled Agaricomycetes new to India. Journal on New Biological Reports 3(2):155-158.

157. Priyanka. 2012. Studies on resupinate Polyporales (Agaricomycetes) of Himachal Pradesh. Ph.D. Thesis. Patiala, India: Punjabi University, Patiala, India.

158. Purkayastha RP, Chandra A. 1976. Indian edible mushrooms. Calcutta, India: Firma K.M. Private Limited.

159. Purkayastha, RP, Chandra A. 1985. Manual of Indian edible mushrooms. New Delhi: Today and Tommorrow's Printers and Publishers.

160. Raghukumar C, Raghukumar S. 1998. Barotolerance of fungi isolated from deep-sea sediments of the Indian Ocean. Aquatic Microbial Ecology 15(2):153–163.

161. Raitvir A, Thind KS, Sharma R. 1985. Four new species of Helotiales from the Eastern Himalayas (India). Eesti NSV Teaduste Akadeemia Toimetised Biologia 34(3):226-231.

162. Ranadive KR, Vaidya JG, Jite PK, Ranade VD, Bhosale SR, Rabba AS, Hakimi M, Deshpande GS, Rathod MM, Forutan A, Kaur M, Naik, Vaidya CD, Bapat GS, Lamrood P. 2011. Checklist of *Aphyllophorales* from the Western Ghats of Maharashtra State, India. Mycosphere p.91–113.

163. Rattan SS. 1974. *Scytinostroma* in India with notes on extralimital species. Transactions of the British Mycological Society 63:1-12.

164. Rattan SS. 1977. The resupinate aphyllophorales of North Western Himalayas. Bibliotheca Mycologica 60:14-27.

165. Rawla GS, Sarwal BM, Arya S. 1982a. Agarics new to India-I. Nova Hedwigia 36:433- 443.

166. Rawla GS, Sharma MP, Narula AM. 1982b. Xylarias new to India. Research Bulletin of Panjab University (Sciences) 33:203-208.

167. Rawla GS, Narula AM. 1984. Xylariaceae from eastern Himalayas-II. Research Bulletin of Panjab University (Sciences) 35(1-2):41-44.

168. Rawla GS, Arya S, Narayan J. 1985. Genera of agarics - new to India. Indian Journal of Mycology and Plant Pathology 14(3):247-251.

169. Rawla GS, Arya S. 1987. Some edible and poisionous agarics new to India. In: Kaul TN, Kapoor BM, eds. Indian Mushroom Science-II. Jammu, India: Regional Research Laboratory. p. 375-382

170. Rawla GS, Locquin MV, Sarwal BM. 1987. Three new species of *Tricholoma* (Fr.) Quel. In: Kaul TN, Kapur BM, eds. Science and cultivation technology of edible fungi. Jammu, India: Council of Scientific and Industrial Research. p. 383-388.

171. Rawla GS, Jain GR, Narula AM. 1989. Wood rot fungi from Andaman and Nicobar Islands-I. Journal of Indian Botanical Society 68(1):59-60.

172. Rawla GS, Arya S. 1991. Studies on agarics of North West India, New species. Boletus 15:11-24.

173. Rawla GS, Prasher IB, Kaur S. 1991a. Addition to discomycetes of Mussoorie Hills-1: operculates. In: Khullar SP, Sharma MP. (eds). Himalayan Botanical Researches. New Delhi: Ashish Publishing House. p. 97-105.

174. Rawla GS, Prasher IB, Kaur S, Sharma MP. 1991b. Addition to discomycetes of Mussoorie Hills-II: Inoperculates. In: Khullar SP, Sharma MP, eds. Himalayan Botanical Researches. New Delhi: Ashish Publishing House. p. 219-222.

175. Rawla GS. 1993. Conservation and significance of Himalayan forest mycoflora. In: Dhar U, ed. Himalayan Biodiversity Conservation Strategies. Nainital, India: Gyanodaya Prakashan. p. 83-85.

176. Rawla, GS. 2000. Common fleshy fungi from Indian Himalaya and adjacent plains. In: Pangtey YPS, ed. High altitudes of the Himalaya-II. Nainital, India: Gyanodaya Prakashan. p. 177-210.

177. Rawla GS, Rawla K, Sharma MP. 2001. Medicinally important agarics in Himalaya. In: Samant SS, Dhar U, Palni LMS, eds. Himalayan Medicinal Plants (Potential and Prospects). Nainital, India: Gyanodaya Prakashan. p. 33-43.

178. Rawla GS. 2001. Himalayan species of *Russula* Pers. ex. S.F. Gray. In: Pandey PC, Samant SS, eds. Plant diversity of the Himalaya. Nainital, India: Gyanodaya Prakashan. p. 1-48.

179. Ritu, Sanyal SK, Dhingra GS. 2015. Some interesting corticioid fungi from district Kangra (H.P.). International Journal of Advanced Life Sciences 8(1): 20-30.

180. Rossman A. 1994. A strategy for an all-taxa inventory of fungal biodiversity. In: Peng CI, Chou CH, eds. Biodiversity and terrestrial cosystems. Academia Sinica Monograph Series No. 14. p. 169-194

181. Roy A, De AB, Pal S. 1994. The genus *Polyporus, s. str.* Fr. in India. Cryptogamic Botany 4(4):381-393.

182. Roy A, De AB. 1995. New or noteworthy records of *Polyporus* from India. Journal of Mycopathological Research 32(2):135-142.

183. Roy A, De AB. 1996a. Polyporaceae of India. Dehradun, India: International Book Distributing Company. 309 p.

184. Roy A, De AB. 1996b. Taxonomy of *Daedalea roseola* comb. *nov.* Mycotaxon 58:413-417.

185. Roy A, De AB. 1996c. Taxonomy of *Fomitopsis rubidus* comb. *nov*. Mycotaxon 60:317-321.

186. Roy A, De AB. 1997a. New records of Polyporaceae from India. Journal of Mycopathological Research 35(1): 63-68.

187. Roy A, De AB. 1997b. Taxonomy of *Daedalea xantha* comb. *nov*. Mycotaxon 61:421-425.

188. Roy A, De AB. 1998a. Taxonomy of *Hexagonia scutellata* comb. *nov.* Journal of Mycopathological Research 36(1):31-35.

189. Roy A, De AB. 1998b. Taxonomy of *Oxyporus lignosus* comb. *nov.* Mycotaxon 67:405-411.

190. Ryvarden L, Dhanda RS. 1975. Two remarkable polypores from India. Transaction of the British Mycological Society 65:413-417.

191. Sagar A, Lakhanpal TN. 1993. Fleshy fungi of N.W. Himalayas-XV: Six species of *Boletus* new to India. Indian Journal of Mycology and Plant Pathology 23(3):227-231.

192. Saini SS, Atri NS, Bhupal MS. 1988. North Indian Agaricales-V. Indian Phytopathology 41:622-625.

193. Saini SS, Atri NS, Saini MK. 1989. North Indian Agaricales-VI. Journal of Indian Botanical Society 68:205-208.

194. Sarbhoy AK, Agarwal DK, Varshney JL. 1996. Fungi of India 1982–1992. New Delhi: CBS Publishers and Distributors. 350 p.

195. Sarbhoy AK. 1998. Biodiversity and biosystematics of agaricales. In: Rai RD, Dhar BL, Verma RN, eds. Advances in Mushroom Biology and Production.

Solan, India: Mushroom Society of India, National Research Centre for Mushroom. p. 31-37.

196. Sarma VV, Hyde KD, Vittal BPR. 2001. Frequency of occurrence of mangrove fungi from the east coast of India. Hydrobiologia 455:41-53.

197. Sarwal BM. 1984. Systematic studies on some Indian Agarics. Ph.D. Thesis. Chandigarh, India: Panjab University.

198. Sathe AV, Rahalkar SR. 1976. Checklist of polyporaceae from South West India-I. Biovigyanum 2:103-105.

199. Sathe AV, Rahalkar SR. 1978. Agaricales from South West India. Biovigyanum 3:119-120.

200. Sathe AV. 1979. Agaricology in India: A review of work done on Indian Agaricales. Biovigyanum 5:125-130.

201. Sathe AV, Deshpande S. 1979. Agaricales of Maharashtra. In: Chattopadhyay SB, Smajpati N, eds. Advances in Mycology and Pathology. New Delhi: Oxford and IBH Publishing Company. p. 82-88.

202. Sathe AV. 1980. Introduction: Agaricales (mushrooms) of South West India. Pune, India: Maharashtra Association for the Cultivation of Science. p. 1-9.

203. Sathe AV, Kulkarni SM. 1987. A checklist of wild edible mushrooms from South West India. In: Kaul TN, Kapoor BM, eds. Indian Mushroom Science-II. Jammu, India: Regional Research Laboratory. p. 411-413.

204. Schmit JP, Shearer CA. 2003. A checklist of mangrove-associated fungi, their geographical distribution and known host plants. Mycotaxon 85:423–477.

205. Sesli E, Tuzen M. 1999. Levels of trace elements in the fruiting bodies of macrofungi growing in the east black sea region of Turkey. Elsevier 65:453-460.

206. Sharda RM. 1984. The genus *Lentaria* Corner in the Himalayas. Biovigyanam 10(2):131-136.

207. Sharda RM, Thind KS. 1986. Genus *Ramaria* in the Eastern Himalaya: subgenus *Laeticolora*-II. Proceedings of Indian Academy of Sciences 96(6):519-529.

208. Sharda RM. 1987. *Clavaria martini* Corner - New to Himalayan mycoflora. Journal of Indian Botanical Society 65(4):522-524.

209. Sharda RM. 1991. Clavarioid homobasidiomycetes in the Himalaya: a checklist. In: Khullar SP, Sharma MP, eds. Himalayan Botanical Researches. New Delhi: Ashish Publishing House. p. 31-60.

210. Sharda RM, Kaushal SC, Negi GS. 1998. Edible fungi of Garhwal Himalayas. Mushroom Research 6(1):11-14.

211. Sharma AD, Munjal RL, Jandaik CL. 1982. Additions to the mycoflora of Himachal Pradesh-XIV. Indian Journal of Mycology and Plant Pathology 12(2):214-216.

212. Sharma BD, Deshpande S, Pradhan, SG. 1986. A new species of *Hygrocybe* Kummer from India. Bulletin of Botanical Survey of India 28(1-4):171-173.

213. Sharma BM. 1982. Studies on Gasteromycetes of Eastern Himalayas and Adjoining Hills. Ph.D. Thesis: Chandigarh, India: Panjab University.

214. Sharma BM, Thind KS. 1990. Some interesting gasteromycetous fungi from eastern Himalaya. Proceeding of Indian Academy of Sciences 100(4):247-254.

215. Sharma BM, Singh BM, Kumar A. 1994. A new edible species of *Leucocoprinus* Pat. Indian Journal of Mycology and Plant Pathology 24(1):83.

216. Sharma JR. 1985. Studies on Polyporaceae of Himachal Pradesh. Journal of Economic and Taxonomic Botany 7(1):95-101.

217. Sharma JR, Ghosh PK. 1989. Polypores that decay trees of Indian Botanic Garden. Bulletin of Botanical Survey of India 31(1-4):95-102.

218. Sharma JR, Wright JE. 1989. A new species of polypores from India. Bulletin of Botanical Survey of India 31(1-4):182-183.

219. Sharma BM. 1991. A new species of *Lycoperdon* from India. Mycological Research 95(9):1144-1145.

220. Sharma JR, Das K. 2001. Mycological trip to Pindari Glacier. Indian Journal Forestry 24(2): 239-244.

221. Sharma JR, Das K. 2003. New and interesting species of *Lactarius* from India. Mycotaxon 88:377-385.

222. Sharma JR. 2012. Aphyllophorales of Himalaya. Calcutta, India: Botanical Survey of India. 590 p.

223. Sharma MP, Sharma R. 1981a. *Lophodermium piceae* (Fuck.) Hohn. (Phacidiaceae): A new record from India. Current Science 50:725-726.

224. Sharma MP, Sharma R. 1981b. *Naemacyclus minor* Butin. Phacidiales: a new record for India. Current Science 50:380-381.

225. Sharma MP. 1982a. *Lophodermium orientale* Minter: A new report from India. Journal Indian Botanical Society 61:451-452.

226. Sharma MP. 1982b. Helotiales: New combinations and records. Nova Hedwigia 36: 709-714.

227. Sharma MP, Sharma R. 1983. The genus *Lophodermium* Chev. (Phacidiales) in India. Bibliotheca Mycologica 91:157-169.

228. Sharma MP. 1985a. Distribution of Cyphellaceae in the Western Himalayas with notes on extralimital species. Research Bulletin of Panjab University (Sciences) 36(1-2):101-109.

229. Sharma MP. 1985b. Himalayan Helotiales: New combinations and record. Acta Biologica Portugaliae Series B 14(1-4):34-36.

230. Sharma MP. 1985c.Three new species of *Lambertella* Hohn. from the Himalayas (India). Egyptian Journal Botany 28(1-3):19-25.

231. Sharma MP, Sharda RM. 1985. The genus *Lanzia* Sacc. in India. International Journal Mycology and Lichenology 2(1):95-117.

232. Sharma MP. 1986a. Ascomycetes new to India-V: Ostropales. Research Bulletin of Panjab University (Sciences) 37(1-2):25-28.

233. Sharma MP. 1986b. Indian Hyaloscyphaceae. Nova Hedwigia 43(3-4): 381-422.

234. Sharma MP. 1986c. New records of discomycetes from Mussoorie Hills. Journal of Indian Botanical Society 65(4):443-445.

235. Sharma MP. 1986d.Two rare fungi (Basidiomycotina) from Western Himalayas. Proceeding of Indian Academy of Sciences 56(1):79-80.

236. Sharma MP, Rawla GS. 1986. Ascomycetes new to India-III. Nova Hedwigia 42(1):81-90.

237. Sharma MP, Sharma V. 1987. Ascomycetes new to India-IV. Annals of Biology 3(1):83-91.

238. Sharma MP. 1991a. Diversity in the Himalayan *Hymenoscyphus* S.F. Gray: an overview. In: Khullar SP, Sharma MP, eds. Himalayan Botanical Researches. New Delhi: Ashish Publishing House. p. 107-211

239. Sharma MP. 1991b. The genus *Poculum* Vel. In: Khullar SP, Sharma MP, eds. Himalayan Botanical Researches. New Delhi: Ashish Publishing House. p. 223-264

240. Sharma MP. 1991c. Wood-rot polypores: a field survey of western Himalayan forests. In: Khullar SP, Sharma MP, eds. Himalayan Botanical Researches. New Delhi: Ashish Publishing House. p. 83-96

241. Sharma MP, Sidhu D. 1991. Notes on Himalayan Geoglossaceae. In: Khullar SP, Sharma MP, eds. Himalayan Botanical Researches. New Delhi: Ashish Publishing House. p. 13-29.

242. Sharma MP, Kamal R. 1993. Diversity and endemism among Indian *Helotiales*. In: Dhar U, ed. Himalayan Biodiversity Conservation Strategies. Nainital, India: Gyanodaya Prakashan Nainital. p. 87-100.

243. Sharma MP, Gupta S. 1994. *Schizophyllum* Fr. In India: Its role in forest ecosystem. In: Khan IA, ed. Frontiers in Plant Science. Hyderabad, India: Syndicate Publishers. p. 113-118.

244. Sharma MP, Gupta S. 2004. Wood-rot fungi from Haryana. In: JS Dargan, TA Sarma, eds. Plant Diversity. Dehradun, India: Bishan Singh Mahendra Pal Singh p. 467-475.

245. Sharma MP, Prasher IB, Soni N. 2007. A checklist of Gasteromycetes of Indian Himalayas. In: Prasher IB, Sharma MP, eds. Advances in Mycology and Plant Pathology. Dehradun, India: Bishen Singh Mahendra Pal Singh. p. 85-137.

246. Sharma R, Arendholz WR, Thind KS. 1986. Some more observations on Eastern Himalayan Helotiales. Mycotaxon 25(1):119-140.

247. Sharma R, Sharma JR, Lakhanpal TN. 1987. Fleshy fungi of North-Western Himalayas-IV. *Austroboletus* (Corner) Wolfe: A new record of a genus from India. Kavaka 14(1-2):41-43.

248. Sharma R, Lakhanpal TN. 1988. Fleshy fungi of North Western Himalayas-VII: the genus *Tylopilus* (Boletaceae). Kavaka 16(1-2):36-39.

249. Sharma R, Prasher IB, Sharma MP. 1998. New species of *Lachnum* Retz. from eastern Himalayas. India. Research Bulletin of Panjab University (Sciences) 48(1-4):29-43.

250. Singh AP. 2007. Resupinate aphyllophoraceous fungi associated with some tree species of Himachal Pradesh and Punjab. Ph.D. Thesis. Patiala, India: Punjabi University, Patiala, India. 258 p.

251. Siva R, Kariyarasan V, Natarajan K. 2006. Agarics from Eastern Ghats, South India-I. Kavaka 34:55-70.

252. Swapna S, Syed Abrar, Krishnappa M. 2008. Diversity of macrofungi in semi-evergreen and moist deciduous forest of Shimoga district, Karnataka, India. Journal Mycology and Plant Pathology 38(1):21-26.

253. Syed Abrar, Swapna S, Krishnappa M. 2008. *Bovista aestivalis* and *Calvatia craniiformis*: New records to India. Journal Mycology and Plant Pathology 38(3):504-506.

254. Thind KS, Anand GPS. 1956a. The Clavariaceae of the Mussoorie Hills (India)-I. Journal of Indian Botanical Society 35:92-102.

255. Thind KS, Anand GPS. 1956b. The Clavariaceae of the Mussoorie Hills-IV. Journal of Indian Botanical Society 35:323-332.

256. Thind KS, Dev S. 1956. The Clavariaceae of the Mussoorie Hills-V. Journal of Indian Botanical Society 35:512-521.

257. Thind KS, Batra LR. 1957a. The Pezizaceae of the Mussoorie Hills-I. Journal of Indian Botanical Society 36:51-60.

258. Thind KS, Batra LR. 1957b. The Pezizaceae of the Mussoorie Hills-IV. Journal of Indian Botanical Society 36:428-438.

259. Thind KS, Dev S. 1957a. The Clavariaceae of the Mussoorie Hills-VI. Journal of Indian Botanical Society 36: 2-103.

260. Thind KS, Dev S. 1957b. The Clavariaceae of the Mussoorie Hills-VIII. Journal of Indian Botanical Society 36:475-485.

261. Thind KS, Batra LR, Sethi JS. 1957a. The Pezizaceae of the Mussoorie Hills-II. Journal of Indian Botanical Society 36:192–206.

262. Thind KS, Batra LR, Saini SS. 1957b. The Pezizaceae of the Mussoorie Hills-III. Indian Phytopathology 10: 26-27.

263. Thind KS, Raswan GS. 1958. The Clavariaceae of the Mussoorie Hills-X. Journal of Indian Botanical Society 37:455-469.

264. Thind KS, Batra LR, Cash EK, Sethi JS. 1958a. The Pezizaceae of the Mussoorie Hills-V. Mycologia 49:831-836.

265. Thind KS, Batra LR, Saini SS, Singh P. 1958b. The Pezizaceae of the Mussoorie Hills-VI. Journal of Indian Botanical Society 38:221-232.

266. Thind KS, Batra LR, Singh P. 1959. The Helotiales of the Mussoorie Hills-II. Mycologia 51:833–839.

267. Thind KS. 1961a. Indian Clavariaceae. New Delhi: Indian Council of Scientific and Industrial Research.

268. Thind KS. 1961b. The Clavariaceae of India. New Delhi: Indian Council of Scientific and Industrial Research. 197 p.

269. Thind KS, Batra LR, Saini SS. 1961. The Helotiales of Mussoorie Hills-I. Journal of Indian Botanical Society 40:295–307.

270. Thind KS, Batra LR, Saini SS, Singh H. 1964a. The Helotiales of India-III. Journal of Indian Botanical Society 43:530-542.

271. Thind KS, Batra LR, Saini SS, Waraitch KS. 1964b. The Pezizales of India-VIII. Journal of Indian Botanical Society 43:459-475.

272. Thind KS, Batra LR, Saini SS. 1965. The Helotiales of India-IV. Journal of Indian Botanical Society 44:122-132.

273. Thind KS, Batra LR, Saini SS. 1966. The Pezizales of India-IX. Journal Indian Botanical Society 45:384-391.

274. Thind KS, Rattan SS. 1967. The Clavariaceae of India-XI. Proceedings of Indian Academy of Sciences 66: 143-156.

275. Thind KS, Batra LR, Saini SS. 1967. The Helotiales of India-VI. Mycologia 59:467-474.

276. Thind KS, Waraitch KS. 1969. Xylariaceae of India-I. Proceedings of Indian Academy of Sciences 70B:131-138.

277. Thind KS, Rattan SS, Dhanda RS. 1969. The Polyporaceae of India-VI. Indian Phytopathology 21:109-117.

278. Thind KS, Rattan SS, Dhanda RS. 1970. The Polyporaceae of India-VI. Research Bulletin (N.S.) of Panjab University 21(1-2):109-117.

279. Thind KS, Rattan SS. 1971. The Polyporaceae of India-VII. Indian Phytopathology 24(2):290-294.

280. Thind KS, Rattan SS. 1972. The Clavariaceae of India-XII. Proceedings of Indian Academy of Sciences 75:51-54.

281. Thind KS. 1973. The aphyllophorales of India. Indian Phytopathology 26:2-23.

282. Thind KS, Dargan JS. 1975. Xylariaceae of India-II. Journal of Indian Botanical Society 54:167-175.

283. Thind KS, Waraitch KS. 1976. Xylariaceae of India-III. Indian Journal of Mycology and Plant Pathology 6:113-120.

284. Thind KS, Dargan JS. 1978a. Xylariaceae of India-IV. The Genus *Daldinia* in India. Kavaka 6:15-24.

285. Thind KS, Dargan JS. 1978b. Xylariaceae of India-V. Journal of Indian Botanical Society 58:285-293.

286. Thind KS, Dhanda RS. 1979.The Polyporaceae of India-IX. Kavaka 7:51-58.

287. Thind KS, Dhanda RS. 1980a.The Polyporaceae of India-X. Kavaka 8:59-67.

288. Thind KS, Dhanda RS. 1980b. The Polyporaceae of India-XI. Indian Phytopathogy 31(4):463-472.

289. Thind KS, Dhanda RS. 1980c. The Polyporaceae of India-XIII. Indian Phytopathology 33(3):380-387.

290. Thind KS, Thind IPS, Sharma BM. 1982. The Gasteromycetes of the Himalayas-IX. Two new hypogeous species. Indian Phytopathology 35:613-615.

291. Thind KS, Sharda RM. 1984. Three new species of clavarioid fungi from Himalayas. Indian Phytopathology 37(2):234-240.

292. Thind KS, Dhingra GS. 1985. Thelephoroid fungi of the Eastern Himalayas-I. Research Bulletin of Panjab University (Sciences) 36(3-4):165-174.

293. Thind KS, Sharda RM. 1985a. Genus *Ramaria* in the eastern Himalaya: Subgenus *Laeticolora*-1. Proceeding of the Indian National Academy of Science 95(4):271-281.

294. Thind KS, Sharda RM. 1985b. Some interesting clavarioid fungi from the Eastern Himalayas. Journal Indian Botanical Society 64(2-3):236-245.

295. Thind KS, Sharda RM. 1985c. The genus *Ramaria* in the eastern Himalayas: subgenera *Ramaria*, *Echinoramaria* and *Lentoramaria*. Proceeding of Indian Academy of Science 95(1):51-64.

296. Thind KS, Sharma R. 1985. *Maasoglossum*, a new genus of the Geoglossaceae from the Eastern Himalayas. Kavaka 12(1): 37-40.

297. Thind KS, Thind IPS, Sharma BM. 1985. The gasteromycetes of the Himalayas-III. Kavaka 12(1):53-57.

298. Thind KS, Sharma R. 1986. New generic and specific records of Helotiales fron India/Himalayas. Kavaka 13(1): 37-45.

299. Thind KS, Sharma BM. 1986a. Gasteromycetes of the Himalayas XI. Journal of Indian Botanical Society 65(3):247-256.

300. Thind KS, Sharma BM. 1986b. Gasteromycetes of the Himalayas XII. Journal of Indian Botanical Society 65(3):257-264.

301. Thind KS, Sharda RM. 1987. The genera *Clavulinopsis* and *Ramariopsis* in the Eastern Himalayas. Kavaka 14(1-2):9-16.

302. Thind KS, Sharma MP. 1987. The Helotiales of India-XVIII. Journal of Indian Botanical Society 65(4): 466-470.

303. Thind KS, Thind IPS. 1988. The Gasteromycetes of the Himalayas-VII. Indian Phytopathology 40(4):451-458.

304. Thind KS, Sharma BM. 1989. The gasteromycetes of the Himalayas-XII. Journal of Indian Botanical Society 68(2-4):265-272.

305. Upadhyay RC, Kaur A, Kumari D, Semwal KC, Gulati A. 2008. New records and taxonomy of agaricales from North-Western Himalaya. Journal of Mycology and Plant Pathology 38(2):158-163.

306. Vaidya JG, Rabba AS. 1995. The genus *Phellinus* from Bhimashankar forest. Biologia Indica 5:47-56.

307. Van der Heijden MGA, Klironomos JN, Ursic M, Moutoglis P, Streitwolf-Engel R, Boller T, Wiemken A, Sanders IR. 1998. Mycorrhizal fungal diversity determines plant biodiversity, ecosystem variability and productivity. Nature 396:69-72.

308. Vane CH. 2003. Monitoring Decay of Black Gum Wood (*Nyssa sylvatica*) During Growth of the Shiitake Mushroom (*Lentinula edodes*) using Diffuse Reflectance Infrared Spectroscopy. Applied Spectroscopy 57(5):514–517.

309. Vasudeva RS. 1952. Fungi of India (Supplement). New Delhi: Indian Council of Industrial Research. p. 206.

310. Vaupotic T, Veranic P, Jenoe P, Plemenitas A. 2008. Mitochondrial mediation of environmental osmolytes discrimination during osmoadaptation in the extremely halotolerant black yeast *Hortaea werneckii*. Fungal Genetics and Biology 45(6):994-1007.

311. Verma RK, Sharma N, Soni KK, Jamaluddin 2008. Forest fungi of central India. Lucknow, India: International Book Distributing Company. 418 p.

312. Verma RN, Singh GB, Bilgrami KS. 1987. Fleshy fungal flora of North Eastern Himalya, India-I: Manipur and Meghalaya. In: Kaul TN, Kapoor BM, eds. Indian Mushroom Science-II. Jammu, India: Regional Research Laboratory. p. 414-421.

313. Verma RN, Singh GB, Mukta Singh S. 1998. Mushroom flora of North Eastern hills. In: Chadha KL, Sharma SR, eds. Advances in Horticulture 13: Mushrooms. New Delhi: Malhotra Publishing House. p. 329-349.

314. Verma RN, Singh SM, Singh TGB, Bilgrami KS. 1989. *Gomphus floccosus* - a new record for India. Current Science 58(24):1370-1371.

315. Virdi SS. 1989a. *Microporellus* Murr. (Polyporaceae): a new record from India. Current Science 58(14):801-802.

316. Virdi SS. 1989b. *Pachykytospora* Kotl. and Pouz. (Polyporaceae): a new generic record from the Himalayas, India. Current Science 58(24):1369-1370.

317. Virdi SS. 1990. Two resupinate, wood decaying poroid fungi new to India. Sydowia 42:209-210.

318. Virdi SS. 1991. Additions to the genus *Trametes* Fr. in eastern Himalayas and adjoining hills. In: Khullar SP, Sharma MP, eds. Himalayan Botanical Researches. New Delhi: Ashish Publishing House. p. 275-284.

319. Virdi SS. 1992. Two *Antrodia* species from Arunachal Pradesh (India). International Journal of Mycology and Lichenology 5(3):307-311.

320. Wallander H, Gadd GM. 2006. Mineral dissolution by ectomycorrhizal fungi: Fungi in biogeochemical cycles, Cambridge, UK: Cambridge University Press. p. 28-50.

321. Wasser S, Weis A. 1994. Medicinal properties of substances occurring in higher basidiomycetes mushrooms. International Journal of Medicinal Mushrooms 1:31-62.

322. Wasser S. 2002. Medicinal mushrooms as a source of antitumor and immunodulating polysaccharide. Journal of Applied Microbiology and Biotechnology 60(3):258-274.

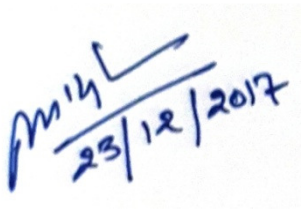
323. Wassink EC. 1978. Luminescence in fungi. In: Herring PJ, ed. Bioluminescence in Action. London, UK: Academic Press. p. 171–195.

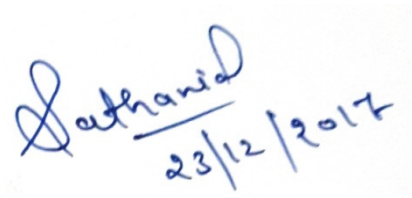
324. Watling R, Gregay NM. 1980. Larger fungi from Kashmir. Nova Hedwigia 32:493-564.

325. Watling R. 1978. Study of Indian agarics. Indian Journal of Mushrooms 4:30-37.

326. Webster J, Weber R. 2007. Introduction to Fungi 3rd edition. Cambridge, U.K.: Cambridge University Press.

327. Zhang BC, Minter DW. 1988. *Tuber himalayense sp. nov.* with notes on Himalayan truffles. Transaction of the British Mycological Society 91:593-597.





SUPERVISOR

Dr. Hem Chander
Assistant Professor,
Department of Bio-Sciences,
Division Botany,
School of Basic & Applied Sciences,
Career Point University, Hamirpur (H.P.)

RESEARCH SCHOLAR

Ms. Jyoti Pathania
Research Scholar (Ph.D.),
Department of Bio-Sciences,
Division Botany,
School of Basic & Applied Sciences,
Career Point University, Hamirpur (H.P.)